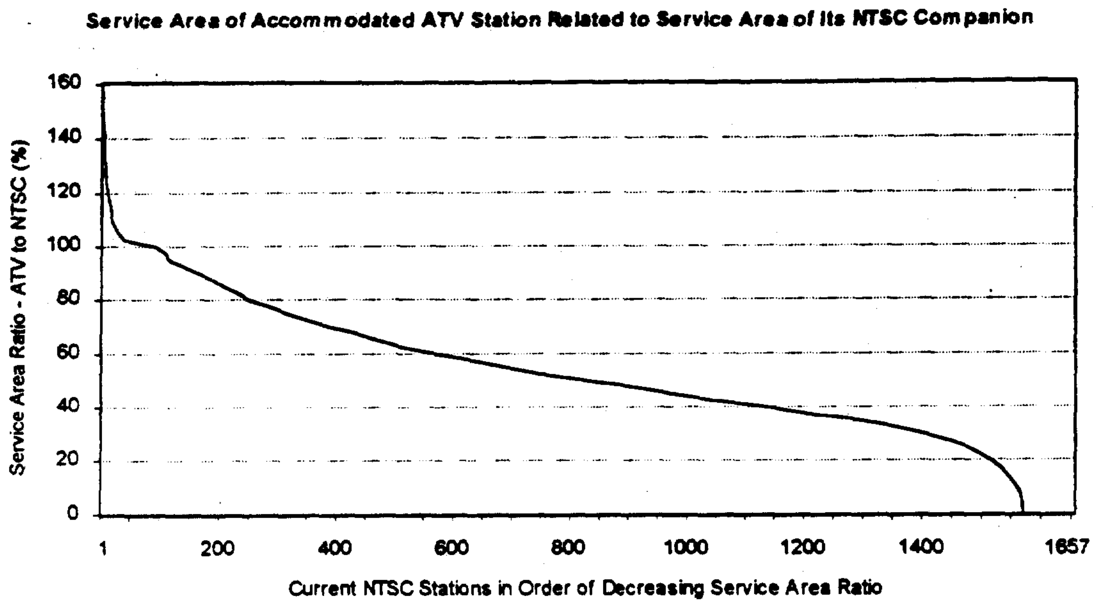


Figure 9-4. Narrow-MUSE UHF Scenario — Interference-limited service area of each ATV station relative to the interference-limited service area of its companion NTSC station (co-channel and adjacent-channel constraints).

Interference Area Compared to Coverage Area	ATV Stations with Interference		NTSC Stations with Added Interference Due to ATV
	During Transition	After Transition	
No Interference	7.8 %	14.2 %	77.7 %
0 - 5 %	2.8 %	3.3 %	7.9 %
5 - 10 %	2.7 %	3.8 %	5.4 %
10 - 15 %	2.8 %	4.2 %	3.8 %
15 - 20 %	4.0 %	4.8 %	2.2 %
20 - 25 %	4.9 %	5.1 %	1.4 %
25 - 30 %	5.3 %	6.0 %	0.9 %
30 - 35 %	5.7 %	5.9 %	0.4 %
> 35 %	64.0 %	52.7 %	0.2 %

Figure 9-5. Narrow-MUSE UHF Scenario — Interference characteristics (co-channel and adjacent-channel constraints).

than 35% of their Grade B coverage area. The total new interference created under this plan is 0.77 million square kilometers.

When the adjacent-channel constraints of Figure 9-1 are not included in the UHF scenario, the allotment/assignment table is different. In that case, 3.4% (56) of the ATV stations would have an ATV service area at least 20% larger than their companion NTSC service area and 41% (673) would have an ATV service area at least 80% of their companion NTSC service area. During the transition period, 19.3% of ATV stations would receive no interference. This would rise to 29.7% after the transition period ends. Also during the transition period, 27.5% of the ATV stations would receive interference in more than 35% of their noise-limited coverage area. This would fall to 21.6% after the transition period ends. Of the existing NTSC stations, 71.2% would not receive any new interference because of the ATV service, while 0.2% would receive new interference in more than 35% of their Grade B area.

The frequency distribution of ATV station effective radiated power levels needed to achieve ATV noise-limited coverage comparable to NTSC Grade B coverage was calculated. The maximum effective radiated power level was limited to 37 dBk (5,000 kW). The results are shown in Figure 9-6.

Effective Radiated Power Level		Number of TV Stations			
		VHF/UHF Scenario			UHF Scenario
(dBk)	(kW)	Low VHF	High VHF	UHF	UHF
Less than 5	Less than 3.2			2	2
5 - 10	3.2 - 10.0	2		5	5
10 - 15	10.0 - 31.6	2	1	35	35
15 - 20	31.6 - 100	1	7	29	30
20 - 25	100 - 316		3	49	48
25 - 30	316 - 1,000			108	108
30 - 35	1,000 - 3,160		1	324	330
35 - 40	3,160 - 10,000			1,013	1,013
> 40	> 10,000				
TOTAL		5	12	1,565	1,571

Figure 9-6. Narrow-MUSE power level distribution.

9.3 ECONOMICS

9.3.1 Cost to Broadcasters

The estimated equipment cost for a Narrow-MUSE transitional station is shown in Figure 9-7. The total cost of the transitional station was estimated to be $1,710,700. The total cost of a minimal station was estimated to be $1,114,300. A general description of the methods used to develop the cost data is contained in Section 8.2.1.

Subsystem	Cost (thousands)
Satellite Receiver, Demodulator, Decoder	$ 13.5
Character Generator, Still Store, Two 28" Monitors	200.0
Routing Switcher (10 x 10), Master Control	125.0
2 ATV VTRs and Monitors	170.0
NTSC Upconverter, including Line Doubler	19.0
ATV-to-NTSC Downconverter	15.0
34" Monitor, Seven 17" Monitors, Eight Decoders	110.0
ATV Encoder	200.0
STL Subsystem	92.5
ATV Modulator, NTSC Exciter	25.0
ATV Transmission Subsystem	740.7
TOTAL COST	$1,710.7

Figure 9-7. Equipment cost for a Narrow-MUSE transitional station.

9.3.2 Cost to Alternative Media

Information on this topic was not provided.

9.3.3 Cost to Consumers

The estimated material cost data for a Narrow-MUSE receiver are shown in Figure 9-8. A general description of the methods used to develop the cost data is contained in Section 8.2.2.

Using a 2.5 multiplier, the resulting estimated retail price for a Narrow-MUSE receiver is $2,620 for a 34" direct view receiver and $3,910 for a 56" projector receiver.

Subsystem	34" Widescreen Direct View Receiver	56" Widescreen CRT Type Projector
Signal Processing Components	$ 168	$ 168
Audio Amplifiers, Speakers	30	30
Scan System, Power Supply, Video Amps	60	176
Display	700	1,050
Cabinet	90	140
TOTAL MATERIAL COST	$1,048	$1,564

Figure 9-8. Material cost data for a Narrow-MUSE receiver.

9.4 TECHNOLOGY

9.4.1 Audio/Video Quality

In video subjective tests of Narrow-MUSE, the system performed differently across segments of test material. For 8 of the 9 stills, Narrow-MUSE was judged, on average, to be about 0.5 grade lower in quality than the 1125-line studio reference. The remaining still, electronically generated, was judged to be better in quality than the reference.[1] For the 14 motion sequences, Narrow-MUSE was judged to be about 1 grade lower in quality than the reference. These quality judgments appear mainly to reflect the static and dynamic resolution limits of Narrow-MUSE as confirmed by the objective measurements. The judgments, however, may also reflect, to some extent, other system characteristics and implementation deficiencies, which resulted in visible artifacts in the Narrow-MUSE images.

No problems were noted for Narrow-MUSE in tests of temporal transient response and response to scene cuts. When subjected to noise at source, however, the system introduced a loss in resolution that was progressive with the level of noise introduced. Further, some problems, which may be significant in light of current distribution practice, were noted when material was subjected to two concatenated Narrow-MUSE encode/decode processes.

There was no evidence that the audio system failed before the accompanying video.

9.4.1.1 Video Quality

Subjective judgments of image quality by non-experts are summarized in Figure 9-9. Scores are the differences between judgments of the reference and judgments of Narrow-MUSE for

[1] See Section 8.3.3.

9 stills and 14 motion sequences.[2] For 8 of the 9 stills, Narrow-MUSE was judged, on average, to be 0.5 grade (i.e., about 10 points on the 100 point scale) lower in quality than the 1125-line studio reference; for the remaining still (S14), the system was judged to be 1.2 grades higher in quality than the reference (this may reflect reduced visibility of interlacing artifacts in the Narrow-Muse rendering of this picture). For motion sequences, Narrow-MUSE was judged, on average, to be 1 quality grade (i.e., about 19 points) lower in quality than the reference.

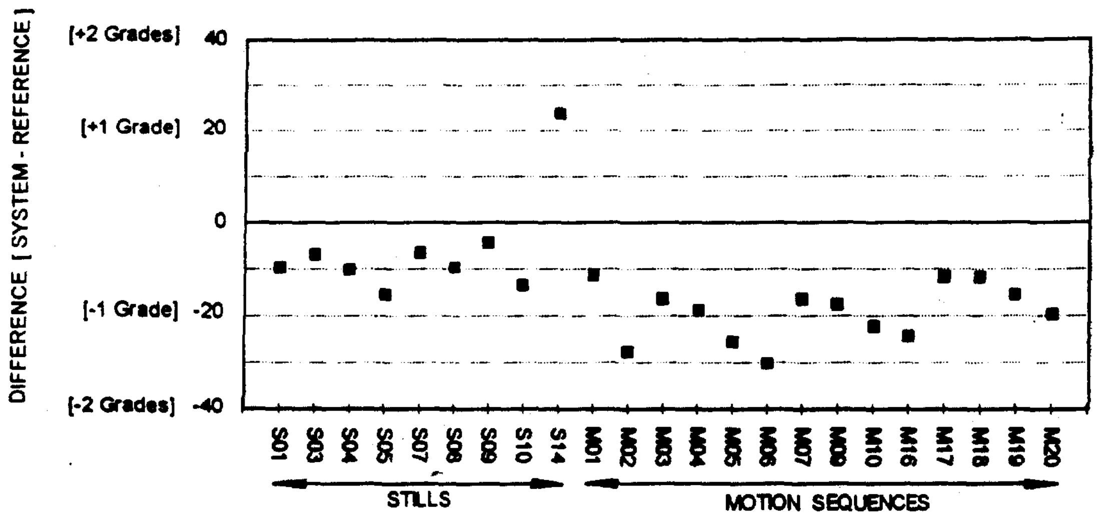


Figure 9-9. Average differences between quality judgments for the 1125-line studio quality reference and for Narrow-MUSE.

Narrow-MUSE performed differently for different segments of test material. For stills, differences ranged from -0.3 to -0.8 grade (not including S14); for moving sequences, differences ranged from -0.6 to -1.5. The variability among viewers differed somewhat across materials, but was within acceptable limits. Analysis of differences in judgment

The conclusion that subjective results primarily reflect resolution limits is supported by objective measurements of static and dynamic resolution. The system showed a decrease in dynamic luminance resolution that is progressive over the range of velocities studied. The conclusion is further supported by expert commentaries, which note a loss in resolution for static material and a greater loss in resolution for dynamic material.[3]

While the data suggest that Narrow-MUSE was judged to be lower in quality than the reference system primarily because of its resolution limits, it is likely that quality judgments for Narrow-MUSE were also influenced by the following system artifacts: reduced fidelity in hue and saturation, ringing, and the introduction of "halos," particularly in dynamic material. Further, it is reasonable to assume that judgments of the system were influenced by visible artifacts caused by implementation deficiencies.

Objective tests were performed for dynamic range, total harmonic distortion (THD), THD+noise (THD+N), intermodulation distortion (IMD), dynamic intermodulation distortion (DIM), frequency response, and overload vs. frequency. The dynamic range for the Narrow-MUSE system was found to be 86 dB. The THD was generally under 0.1%, rising to 0.8% for the high level 20 Hz test in channel 1. Channel 2 showed 16% THD under the same condition. For high level signals, THD+N was 0.05% in the mid band, rising to nearly 1% at 20 Hz and 10 kHz. Channel 2 showed aberrant behavior for low frequencies, similar to that shown in the THD test. IMD was under 0.03% in channel 1, and under 0.1% in channel 2. Frequency response was very flat from 20 Hz to nearly 15 kHz. The system overload point was uniform from 50 Hz to 5 kHz, dropped 8 dB at 20 Hz, and 3 dB at 8 kHz. No overload data are available at 15 kHz since the system response did not extend that far.

In the test of co-channel ATV-into-NTSC, Narrow-MUSE caused no interference into BTSC audio, and degraded NTSC VBI data only at the highest level of the ATV undesired signal. With Narrow-MUSE as an upper adjacent-channel, the amount of interference in the three NTSC receivers varied from no interference in one receiver, gradual impairment with increasing interference in the second receiver, to constant interference in the third receiver.

9.4.2 Transmission Robustness

When exposed to impairments such as random channel noise, multipath or co-channel interference, Narrow-MUSE exhibited gradual or graceful degradation characteristics, similar to NTSC. It performed similarly relative to NTSC for impulsive noise. With the exception of two of the six adjacent-channel interference tests, Narrow-MUSE equalled or exceeded the interference susceptibility (more robust) of NTSC (see Figure 9.1). Narrow-MUSE has

31.8 dB.[5] Random noise appeared as snow, as in NTSC. Channel noise did not cause motion artifacts.

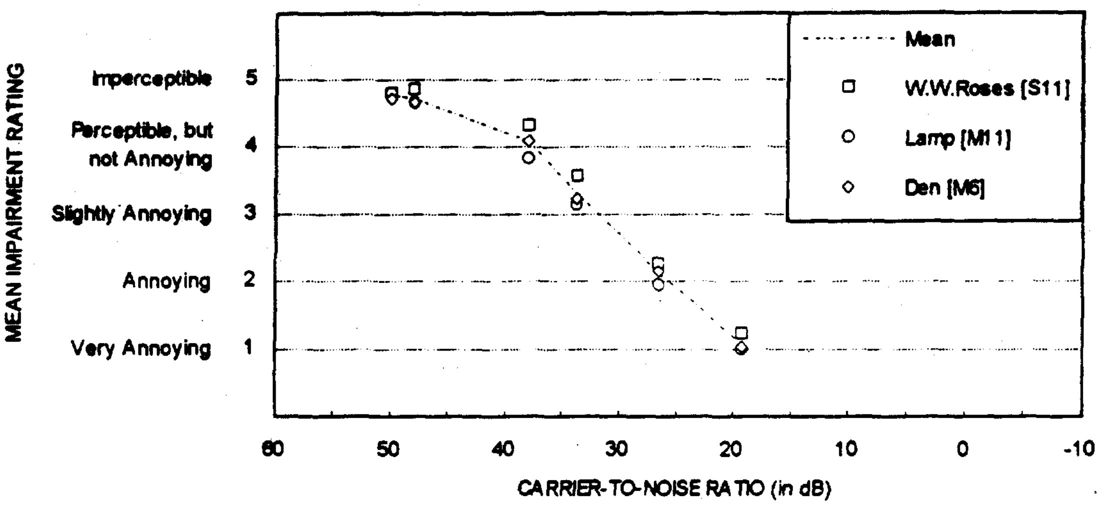


Figure 9-10. The performance of Narrow-MUSE when subjected to random noise.

9.4.2.2 Static Multipath

Ghosts on Narrow-MUSE have a similar appearance as ghosts on NTSC. The adaptive equalizer had a convergence time of the order of 20 seconds. A residual leading ghost was present during this test, even when no impairment was added, due to the particular implementation of the equalizer. The TOV for ghosts of +0.08 μsec and +0.32 μsec were at a D/U around 30 dB (3.3%). The TOV for a ghost of -0.08 μsec could not be measured due to the presence of the residual ghost. The TOV for the +2.56 μsec ghost could not be found because of the presence of the leading ghost and periodicity in the test picture. Ghost levels for the points of unusability were significantly higher than for the points of acquisition, reflecting a strong hysteresis.

[5] Caution must be exercised in comparing C/N between analog and digital systems, as definition of carrier levels is not consistent. Measurement of power level is consistent, however, among digital systems. (See Section 8.3.6.)

9.4.2.3 Flutter

The TOV for airplane flutter of 2 Hz and 5 Hz were at D/U levels of 40.6 dB (0.93%) and 43.6 dB (0.66%) respectively. These results are substantially lower than for static multipath due presumably to the long convergence time of the equalizer.

9.4.2.4 Impulse Noise

Impulse noise performance appears to be equivalent to NTSC.

9.4.2.5 Discrete Frequency Interference

D/U ratios at the TOV for discrete frequency interference were 24 $\pm$ 2 dB in the first upper and lower adjacent-channels, and ranged from 55 dB to 38 dB in-band.

9.4.2.6 Cable Transmission

The subjective tests show that cable transmission *per se* has no adverse effect on Narrow-MUSE performance; however, the poor adjacent-channel interference performance of the tested receiver is a major concern for cable system adjacent-channel operation. The system performed much better than NTSC with composite triple beat interference. Phase noise and residual FM performance was poor compared to NTSC.

9.4.2.7 Co-Channel Interference into ATV

The Narrow-MUSE spectrum has a notch at frequencies around the NTSC visual carrier, which provides for a better co-channel performance than NTSC-into-NTSC.

The system exhibits a graceful degradation with co-channel interference: impairment ratings vary from "imperceptible" to "very annoying" over a range of 16 dB for NTSC-into-ATV interference (Figure 9-11) and over a range of 17 dB for ATV-into-ATV interference (Figure 9-12). Expert observers described co-channel interference into Narrow-MUSE as a lattice or herringbone pattern. System-specific tests have shown that channel frequency offset has no effect on the co-channel performance of Narrow-MUSE.

9.4.2.8 Co-Channel Interference into NTSC

For co-channel interference into NTSC, impairment ratings vary from "imperceptible" to "very annoying" over a range of 15 dB. See Figure 9-13.

9.4.2.9 Adjacent-Channel Interference

When compared with NTSC interference into NTSC, Narrow-MUSE exhibited poor performance in lower adjacent-channel interference from NTSC and in upper adjacent-

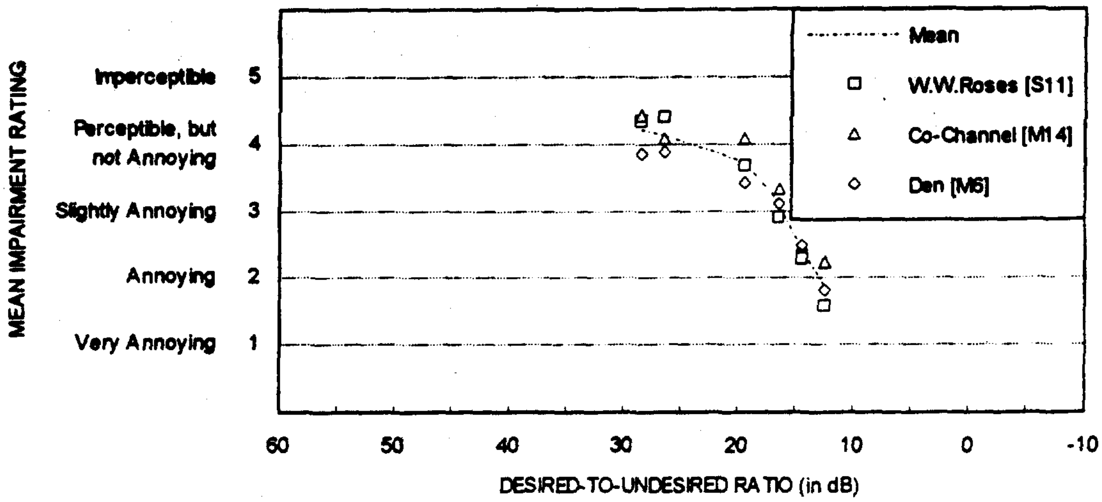


Figure 9-11. The performance of Narrow-MUSE when subjected to NTSC co-channel interference for weak signal condition (-58 dBm).

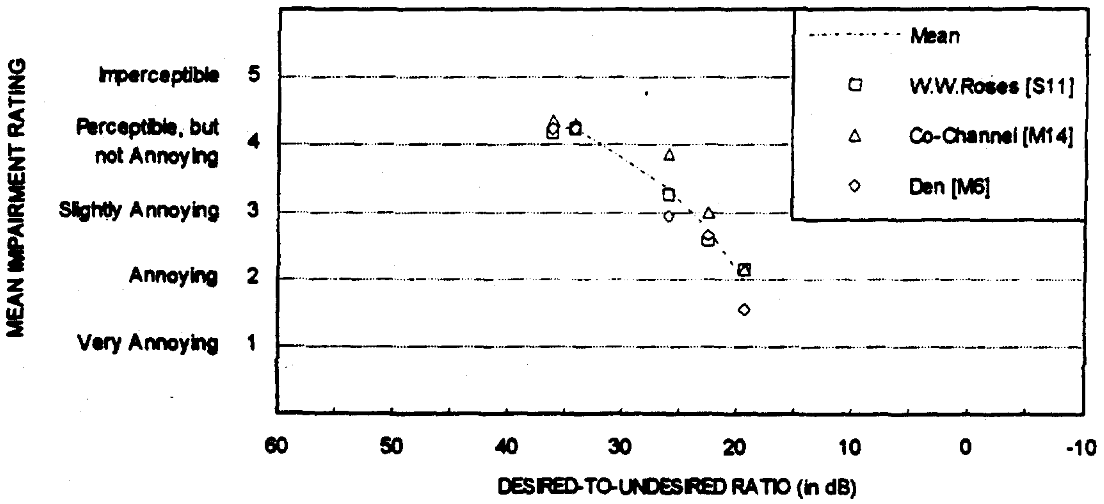
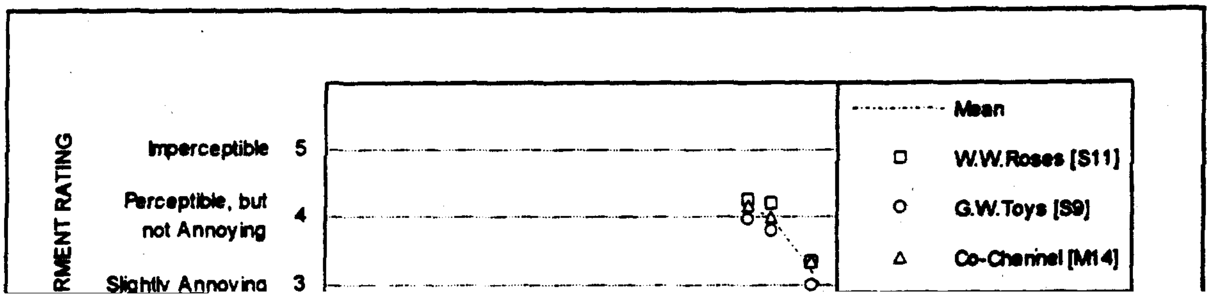


Figure 9-12. The performance of Narrow-MUSE when subjected to ATV co-channel interference for weak signal condition (-58 dBm).

channel interference from ATV. Of the six adjacent-channel interference tests, the four tests of interference into ATV exhibit impairment ratings that vary from "imperceptible" to "very annoying" over a range of 7 to 25 dB. The two tests of interference into NTSC exhibit a range of 12 and 13 dB.



CHANNEL	ATV-into-NTSC		NTSC-into-ATV		ATV-into-ATV	
	Strong	Weak	Strong	Weak	Strong	Weak
n+2	-8	-32	+2	-10	-1	-15
n-2	<-10*	-32	+1	-12	-14	-25
n+4	<-10*	-27	-19	-31	-18	-33
n+7	**	**	**	**	**	**
n-7	<-10*	<-40*	<-23*	<-43*	<-23*	<-43*
n+8	**	**	**	**	**	**
n-8	<-10*	<-40*	<-23*	<-43*	<-23*	<-43*
n+14	<-10*	<-40*	<-23*	<-43*	<-23*	<-43*
n+15	<-10*	<-28*	<-23*	<-43*	<-23*	<-43*

* Determination of TOV level was beyond the limits of ATTC's RF test bed range. Consequently, the system performance was better than the indicated result.

** Test not performed.

Figure 9-14. Taboo threshold of visibility for Narrow-MUSE (D/U in dB).

9.4.3 Scope of Services and Features

9.4.3.1 Data

Narrow-MUSE provides 128 kbits/sec of ancillary data. The interface for the data channel is RS-422. All data services are transmitted using the ancillary data channel.

9.4.3.2 Encryption

The system submitted for testing did not include encryption. The proponent suggests a combination of line rotation and line permutation for signal security for which decoder chips are already developed.

9.4.3.3 Addressing

The addressing information is transmitted through the ancillary data channel.

9.4.3.4 VCR Capability

The proponent claims that a digitized Narrow-MUSE signal with an 80-Mbits/sec data rate or a DPCM-encoded Narrow-MUSE signal with a 40-Mbits/sec data rate can be digitally recorded on a 1/2 inch cassette VCR.

The proponent claims that the quality of a rapid search picture will be comparable to that of a 4-head VHS machine. Only sync blocks whose ID signals are detected correctly are used for fast forward and reverse. Sync blocks whose ID signals are not detected correctly are replaced with interpolated information. These functions can be achieved based on the four-field sequence of the Narrow-MUSE algorithm. Editing functions can be implemented by adjusting the subsampling phases between the materials to be edited using the subsampling phase information which is transmitted as a part of the control signal. Special effects are not done with the Narrow-MUSE signal.

9.4.4 Extensibility

9.4.4.1 To No Visible Artifacts

MUSE-T, a higher member of the MUSE family claimed to provide a picture with no visible artifacts, has a bandwidth of 16.2 MHz and employs only intrafield subsampling. A digitized MUSE-T can be further compressed using DPCM. The main part of a Narrow-MUSE receiver can be shared for MUSE-T decoding when MUSE-T is transmitted through alternate media such as DBS.

9.4.4.2 To Studio Quality Data Rate

It is possible to extend Narrow-MUSE to 240M by transmitting the difference between the locally decoded Narrow-MUSE and 240M signals through an additional channel as augmentation information. The bandwidth of the studio-quality signal is 60 MHz (30 MHz for luminance signal and 15 MHz for each color-difference signal).

9.4.4.3 To Higher Resolution

The proponent suggests that it is possible to extend Narrow-MUSE to VHDTV and UHDTV by transmitting the difference between the locally decoded Narrow-MUSE and VHDTV/UHDTV through an additional channel as an augmentation signal.

9.4.4.4 Provision for Future Compression Enhancement

The proponent claims that the dynamic resolution can be improved by increasing the number of motion vectors. The additional motion vectors can be transmitted through the data channel at the expense of data for other purposes.

9.4.5 Interoperability Considerations

9.4.5.1 With Cable Television

Information on the performance of Narrow-MUSE over cable can be found in Section 9.4.2.6.

9.4.5.2 With Digital Technology

While the transmitted signal is analog, all of the signal processing in the encoder, modulator, demodulator, and decoder is performed in the digital domain. A digital interface port is provided in the receiver for the digitized transmitted signal.

9.4.5.3 Headers/Descriptors

The proponent states that headers/descriptors could be assigned into the ancillary data channel of Narrow-MUSE.

9.4.5.4 With NTSC

There are two conversion methods from Narrow-MUSE to NTSC — from the 750-line transmission format and from the 1125-line display format. The conversion from the transmission format requires only vertical interpolation because Narrow-MUSE employs an analog transmission technique. The conversion from 1125/60 also would require horizontal interpolation. In both conversions, field-rate conversion from 60.00 Hz to 59.94 Hz is required. The proponent claims that a motion-adaptive field-rate converter is available and is used for the daily simulcast operation in Japan. A frame skip must take place every 33 seconds, because of the 1001/1000 frame conversion. The hardware attempts to perform this cut on a motionless picture or on a scene change. The proponent also claims that a converter from MUSE-E to home display is sold on the market, and that the same technique can be applied to Narrow-MUSE.

9.4.5.5 With Film

This system does not have a film mode within its encoding algorithm. Since the field rate of this system is 60 Hz, the temporal conversion from film to HDTV is accurate. Use of 24 fps film still requires 3:2 pull-down. A motion-compensated continuous-film-transfer telecine is already available for this system.

9.4.5.6 With Computers

Progressive scanning and square pixels, not included in the Narrow-MUSE system tested, are important factors for interoperability of an HDTV system with computers. The shape of the displayed Narrow-MUSE pixel format of 1440 (H) x 1035 (V) is 1:0.78. The proponent claims that the field rate of 60.00 Hz is a better selection than 59.94 Hz for interoperability with computers that have integer field rates such as 72 Hz.

9.4.5.7 With Satellites

This system can be transmitted through a satellite using FM with an RF channel bandwidth of approximately 15 MHz. FM transmission of MUSE-E through a satellite is a proven technology. The proponent claims that Narrow-MUSE also can be transmitted through a satellite using digital transmission. The Narrow-MUSE signal can be encoded by DPCM to a data rate of approximately 40 Mbits/sec which includes error correction of 8%. Satellite links typically use more error correction than this, e.g., 14% to 50%. The RF channel bandwidth with QPSK is approximately 24 MHz. Digital transmission of MUSE-E in conjunction with DPCM is also a proven technology.

9.4.5.8 With Packet Networks

Packetizing is not practical because this system employs analog transmission.

9.4.5.9 With Interactive Systems

According to the proponent, the total delay for Narrow-MUSE through an encoder and a decoder is 6 fields (approximately 100 msec), 3 fields for each. Acquisition time is reported in Section 9.4.2.11.

9.4.5.10 Format Conversion

9.4.5.10.1 With 1125/60

No vertical or temporal format conversion is required because this system uses 1125/60 format. The decoded Narrow-MUSE signal can be converted to the Common Image Format (1920 x 1080) through a vertical and horizontal sample rate conversion. These are 24:23

9.4.5.11 Scalability

This system uses a multiple sub-sampling technique with a four-field sequence. Therefore, the spatial resolution of the reconstructed picture can be controlled by selecting fields to be used for the interpolation. When all four fields are used, a full-quality picture is obtained. When one of every four fields is used, a picture with reduced resolution can be obtained by interpolation. Also, a picture with reduced size can be obtained by using only a selected field. The proponent claims that the MUSE family is based on the concept of scalability. The MUSE family consists of MUSE-T, MUSE-E (full-band MUSE), Narrow-MUSE, and NTSC MUSE-4, all based on the same coding algorithm. All these systems have been demonstrated.

For display on a computer, pictures reduced by $1/2^n$ can be made with only intrafield information. Other ratios require more processing. Since this system uses a multiple sub-sampling technique with a four-field sequence, the temporal resolution of the reconstructed picture can be controlled by selecting fields to be used for the interpolation. When all four fields are used, full temporal resolution, 1/60 sec, is obtained. To reduce the amount of data, the field repetition rate can be reduced for pictures with less temporal resolution. The multiple sub-sampling technique makes possible two types of receivers differing in complexity. A simple receiver can be built that handles only intrafield interpolation, while the full-capability receiver handles both intrafield and interfield interpolation.

The low-frequency component below 2 MHz of the Narrow-MUSE signal does not contain the aliasing component caused by frame offset sub-sampling. Therefore, a picture whose quality is equivalent to NTSC can be reproduced by using only this low-frequency component. Picture-in-picture, picture-out-of-picture, and multiple programs can be accommodated using only the intrafield information from the Narrow-MUSE signal. A frame store in the receiver can be used for this purpose.

9.5 SYSTEM IMPROVEMENTS

9.5.1 Already Implemented

9.5.1.1 Modified PLL/AGC Circuit

The PLL/AGC circuit in the Narrow-MUSE receiver has been modified to improve lower adjacent-channel NTSC-into-ATV interference and upper adjacent-channel ATV-into-ATV interference. The input signal to the PLL and AGC circuits, which was originally connected to the output of the IF filter, has been connected to the output of the band-pass filter that is cascaded with the IF filter and used for sync separation. In addition, the width of the sampling pulse in the AGC circuit has been modified to maximize the aperture effect.

9.5.1.2 Corrected ROM's for Digital Roll-Off Filter

The wrong set of ROM's, which was installed in the tested receiver accidentally, has been replaced with the correct set of ROM's. The purpose of this modification was to improve upper adjacent-channel ATV-into-ATV interference.

9.5.1.3 Modified Ghost Canceling Algorithm and Added Channel Memories

The ghost canceling algorithm has been modified to reduce the residual ghost and the convergence time. Parameters, such as the threshold values that decide whether the ghost canceling operation is activated and evaluate the status of convergence, have been modified. Also the integration loop for the received training signal has been modified to improve the SN ratio. These modifications are software changes.

Channel memories have been added to reduce convergence time. The values of the tap coefficients are stored after convergence.

9.5.1.4 Modified Clock Timing and Control Pulse Timing

The purpose of these modifications was to eliminate artifacts that were observed on the screen but had nothing to do with the compression algorithm. These artifacts consisted of white sparkles and a black and white area at the left side of the screen.

9.5.1.5 Adjusted RF/IF Amplifiers and Frequency Converter Circuit

To improve taboo performance, the RF/IF amplifiers and the frequency converter have been adjusted to improve linearity.

9.5.1.6 Fixed ALC Circuit

To reduce channel acquisition time, the reset value of the up-down counter in the ALC circuit, which was accidentally set to its maximum value, has been set to the center value.

9.5.1.7 ATSC T3/186 Functionality

Audio/data channels, with 1.184 Mbits/sec packetized transmission capability, were installed in the Narrow-MUSE hardware delivered to ATTC. The 1.184 Mbits/sec data are forward error protected. The proponent believes the data capacity is large enough to support the various services described in ATSC T3/186.

The proponent does not have a specific proposal for the five-channel audio at this moment and is waiting for the results of the CCIR or ISO-MPEG work. The proponent also is ready to accept a five-channel audio system standardized by other appropriate standardization bodies. Therefore, the five-channel audio capability will not be incorporated in the Narrow-MUSE hardware before field testing.

9.5.2 Implemented in Time for Field Testing

No improvements were proposed for this category.

10. DIGICIPHER

10.1 SYSTEM OVERVIEW

DigiCipher, proposed by the American Television Alliance (General Instrument Corporation and the Massachusetts Institute of Technology) is a digital simulcast system that requires a single 6 MHz television transmission channel. The DigiCipher video source is an analog RGB signal with 1050 lines, 2:1 interlaced, a 59.94 Hz field rate, and an aspect ratio of 16:9. The video sampling frequency is 53.65 MHz. The image in a single frame consists of

Co-Channel	D/U (dB)
ATV-into-NTSC	+35
NTSC-into-ATV	+7.6

Adjacent-Channel	D/U (dB)
Lower ATV-into-NTSC	-13.5
Upper ATV-into-NTSC	-21

When taboos are included in the interference calculations for the VHF/UHF scenario, the number of ATV stations with no interference during the transition period is 34.0%; the number of ATV stations with interference in more than 35% of their noise-limited coverage area is 4.8%. The number of NTSC stations receiving no new interference is 54.4%; the number of NTSC stations with interference in more than 35% of their Grade B area is 2.3%.

When the adjacent-channel constraints of Figure 10-1 are not included in the VHF/UHF scenario, the allotment/assignment table is different. In that case, 15.6% (259) of the ATV stations would have an ATV service area at least 20% larger than their companion NTSC service area and 98% (1,629) would have an ATV service area at least 80% of their companion NTSC service area. During the transition period, 71.9% of ATV stations would receive no interference. This would rise to 85.5% after the transition period ends. Also during the transition period, 1.1% of the ATV stations would receive interference in more than 35% of their noise-limited coverage area. This would fall to 0.5% after the transition period ends. Of the existing NTSC stations, 64.2% would not receive any new interference because of the ATV service, while 2.0% would receive new interference in more than 35% of their Grade B area.

Figure 10-4 depicts the interference-limited service area of each ATV station, during the transition period, relative to the interference-limited service area of its companion NTSC station under the UHF scenario, taking into account both co-channel and adjacent-channel constraints. In this graph, as before, the 1,657 current NTSC stations are placed in order of decreasing ATV to NTSC service area ratio. Examination of the graph reveals that 8.5% (141) of the ATV stations under this scenario would have an ATV service area at least 20% larger than their companion NTSC service area and 92% (1,528) would have an ATV service area at least 80% of their companion NTSC service area. The total ATV interference-limited service area for all 1,657 stations is 38.5 million square kilometers.

Figure 10-5 shows the interference statistics for the UHF scenario. During the transition period, 45.7% of ATV stations would receive no interference. This would rise to 60.3% after the transition period ends. Also during the transition period, 4.6% of the ATV stations would receive interference in more than 35% of their noise-limited coverage area. This would fall to 3.0% after the transition period ends. The total interference area created within the ATV noise-limited coverage area during the transition period is 3.71 million square kilometers. This would decrease to 2.13 million square kilometers after the transition period ends. Of the existing NTSC stations, 62.9% would not receive any new interference because of the ATV service, while 7.6% would receive new interference in more than 35% of their Grade B coverage area. The total new interference created under this plan is 2.12 million square kilometers.

When taboos are included in the interference calculations for the UHF scenario, the number of ATV stations with no interference during the transition period is 36.7%; the number of ATV stations with interference in more than 35% of their noise-limited coverage area is

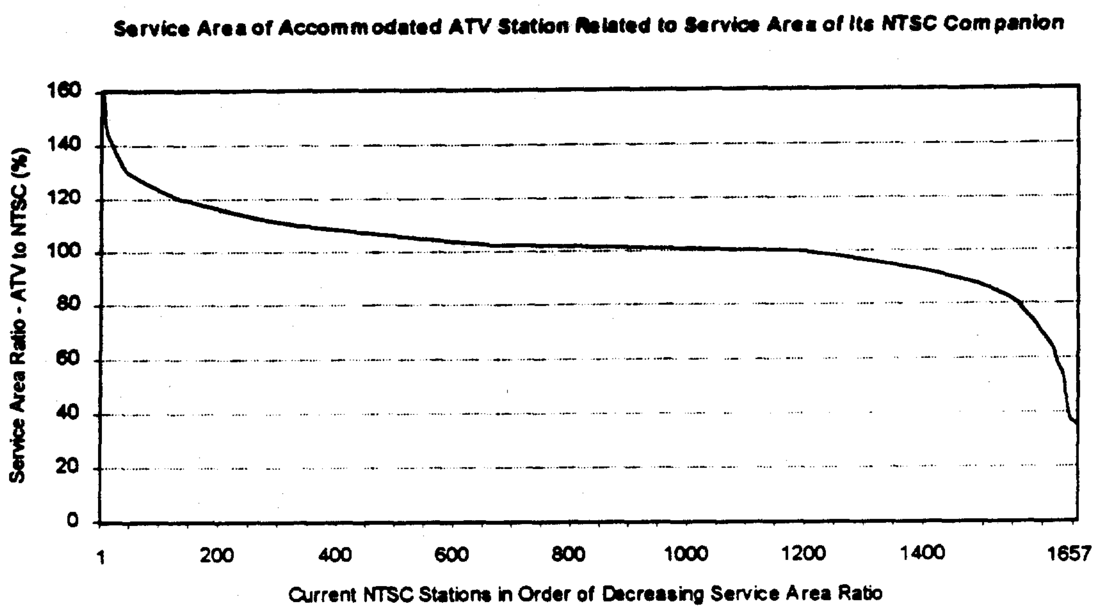


Figure 10-2. DigiCipher VHF/UHF Scenario — Interference-limited service area of each ATV station relative to the interference-limited service area of its companion NTSC station (co-channel and adjacent-channel constraints).

Interference Area Compared to Coverage Area	ATV Stations with Interference		NTSC Stations with Added Interference Due to ATV
	During Transition	After Transition	
No Interference	42.4 %	60.2 %	60.1 %
0 - 5 %	17.0 %	17.7 %	15.9 %
5 - 10 %	12.1 %	9.0 %	8.5 %
10 - 15 %	10.0 %	5.8 %	5.5 %
15 - 20 %	6.5 %	2.7 %	4.0 %
20 - 25 %	3.7 %	1.4 %	1.8 %
25 - 30 %	2.2 %	0.5 %	1.4 %
30 - 35 %	1.9 %	0.8 %	0.7 %
> 35 %	4.2 %	1.8 %	2.1 %

Figure 10-3. DigiCipher VHF/UHF Scenario — Interference characteristics (co-channel and adjacent-channel constraints).

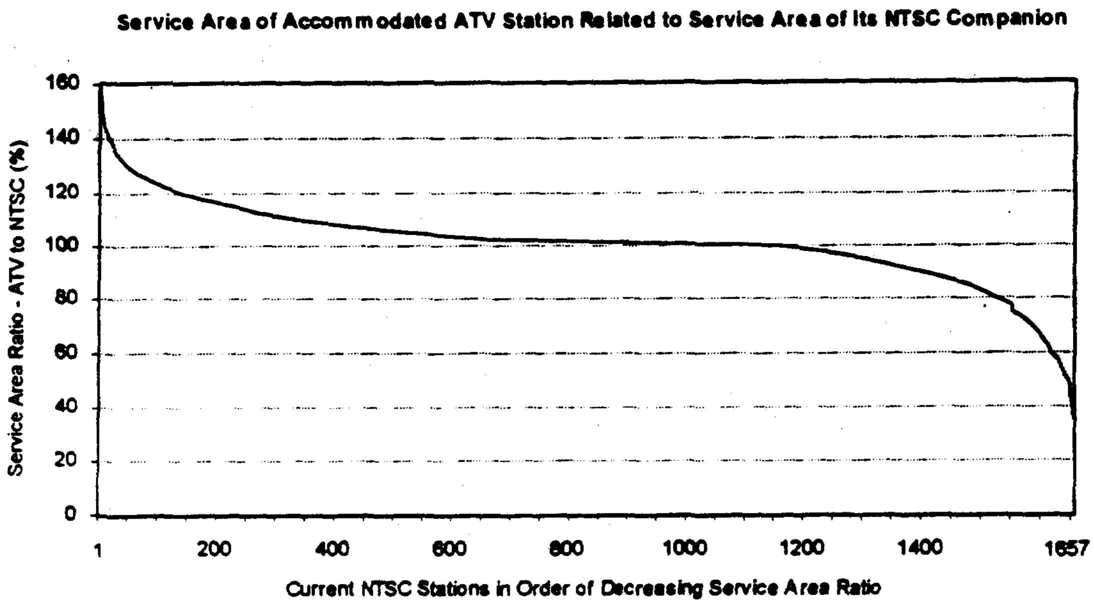


Figure 10-4. DigiCipher UHF Scenario — Interference-limited service area of each ATV station relative to the interference-limited service area of its companion NTSC station (co-channel and adjacent-channel constraints).

Interference Area Compared to Coverage Area	ATV Stations with Interference		NTSC Stations with Added Interference Due to ATV
	During Transition	After Transition	
No Interference	45.7 %	60.3 %	62.9 %
0 - 5 %	13.5 %	14.5 %	8.4 %
5 - 10 %	10.0 %	8.0 %	6.3 %
10 - 15 %	7.8 %	6.3 %	3.9 %
15 - 20 %	6.8 %	3.7 %	3.3 %
20 - 25 %	5.2 %	1.5 %	3.0 %
25 - 30 %	3.1 %	1.4 %	2.5 %
30 - 35 %	3.2 %	1.4 %	2.0 %

6.1%. The number of NTSC stations receiving no new interference is 58.5%; the number of NTSC stations with interference in more than 35% of their Grade B area is 7.6%.

When the adjacent-channel constraints of Figure 10-1 are not included in the UHF scenario, the allotment/assignment table is different. In that case, 12.7% (210) of the ATV stations would have an ATV service area at least 20% larger than their companion NTSC service area and 96% (1,587) would have an ATV service area at least 80% of their companion NTSC service area. During the transition period, 59.2% of ATV stations would receive no interference. This would rise to 75.3% after the transition period ends. Also during the transition period, 2.2% of the ATV stations would receive interference in more than 35% of their noise-limited coverage area. This would fall to 1.9% after the transition period ends. Of the existing NTSC stations, 64.8% would not receive any new interference because of the ATV service, while 7.1% would receive new interference in more than 35% of their Grade B area.

The frequency distribution of ATV station average effective radiated power levels needed to achieve ATV noise-limited coverage comparable to NTSC Grade B coverage was calculated. The maximum average effective radiated power level was 38.23 dBk (6,650 kW). The results are shown in Figure 10-6.

Average Effective Radiated Power Level		Number of TV Stations			
		VHF/UHF Scenario			UHF Scenario
(dBk)	(kW)	Low VHF	High VHF	UHF	UHF
Less than 5	Less than 3.2	12	24	100	100
5 - 10	3.2 - 10.0	3	8	47	48
10 - 15	10.0 - 31.6	2	11	129	138
15 - 20	31.6 - 100		4	251	258
20 - 25	100 - 316			288	302
25 - 30	316 - 1,000			240	254
30 - 35	1,000 - 3,160			317	327
35 - 40	3,160 - 10,000			221	230
> 40	> 10,000				
TOTAL		17	47	1,593	1,657

Figure 10-6. DigiCipher power level distribution.

10.3 ECONOMICS

10.3.1 Cost to Broadcasters

The estimated equipment cost for a DigiCipher transitional station is shown in Figure 10-7. The total cost of the transitional station was estimated to be $1,700,500. The total cost of a